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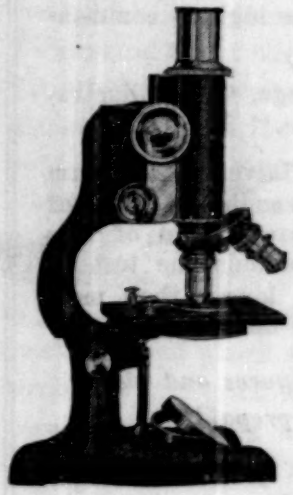

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A PROGRAM FOR AGRICULTURAL DEVELOPMENT[1]

I AM quite conscious that the announcement of the topic for this address may lead to a feeling that it is one which has already been overdiscussed. As Mark Twain said about the weather, "Everybody talks about it, but nobody seems to do anything about it." The choice of a topic for such an address as this is not an easy task. But since the annual meeting of the Association for the Advancement of Science has come to be a sort of milestone to mark the contributions of science to the general public welfare, it seems to me that it would be appropriate to discuss briefly some of the contributions which economic science is making to the problems of agriculture in its relation to public welfare in these days when so much public attention is being given to these matters.

In this country, where public policies are so largely dependent upon and determined by public opinion, a wise program for the development of agriculture as a most important element in the public welfare of the country is most desirable under all conditions, and in periods of depression and economic stress, it is of greatest importance that there be such a wise program, because at such times many irrational or unwise proposals for the amelioration of agricultural conditions are made. These latter may be either based upon an inadequate knowledge of the real needs of agriculture or of the economic laws which govern the development of any industry, or they may be prompted by selfish desires to take personal or political advantage of the unrest and discontent caused by the temporary adverse conditions.

Such a program must be based upon a recognition of the interrelations and interdependence of agriculture and industry. Industry has more to gain and more to lose from a successful or an unsuccessful agriculture than do the farmers themselves in all those states where industry and agriculture are competing for labor and for food and raw products. Director Haskell, in his presidential address before the American Society of Agronomy[2] in Chicago last month, pointed out that through the introduction of improved methods of operation, during the two decades from

[1] Address of the vice-president and chairman of Section O—Agriculture—American Association for the Advancement of Science, Cincinnati, December, 1923.

[2] *Jour. Am. Soc. Agron.*, Vol. 15, No. 12, pp. 473–481. (December, 1923).

1900 to 1920, agriculture was able to release to the industry and commerce of the country over 4,000,000 men, and this without causing any loss but rather a slight gain in the total tonnage production of food and fiber crops in the farms of the country. Further, with a decrease in twenty years in the cultivated acreage of 11 per cent. and of the proportion of our working population which is engaged in farming of over 33 per cent., our farmers have fed and clothed our rapidly growing urban and city population, and in war time have contributed enormously to the needs of the old world countries for these products. While this is a matter for congratulation in many ways, it has its sinister side so far as the present and immediate future condition of agriculture is concerned. Labor moves from place to place and from occupation to occupation in response to the opportunities and returns which are offered to it. What does it mean, then, that 4,000,000 workers transferred from agriculture to other occupations during the twenty years when conditions were the most favorable to agricultural development that the country has seen in the last century? There seems to be no other alternative conclusion than that they went to better their conditions. Hence, if agriculture has benefited by all the scientific work which has been done in its behalf during these years, it would seem that industry and commerce have benefited still more.

Again, such a program must be based upon sound economic principles rather than upon temporary political expedients. There are economic laws which govern the cost of production of farm products, the proper method of their distribution, the financing of farm operations, the consumption of food and fiber, and their ultimate price to the consumer, in just as definite and sure a way as do the physical laws of the universe govern the climate, the soil, the growth of plants and animals and all the other physical phenomena of farm operations. It is as futile to attempt to overthrow these economic laws by legal enactments as it would be to attempt to change the seasons by edict, or to stop the oncoming tide of the ocean by the waving of an imperial scepter. It appears that the present political practise of increasing the cost to the farmer of nearly everything which he has to buy by tariffs on the industrial products which he must use, by guaranteed incomes to transportation agencies which carry his products to market, and by shortened hours of labor at increased wages for the producers of his fuel, etc., has led many otherwise sane and sound farmers to believe that the way out of the present unfair situation is to erect similar artificial barriers about the distribution and sale of his products. Nothing can be more certain, however, than that permanent improvement in conditions can come about only through procedures which are in accord with definite economic laws.

Finally, such a program ought to be national in scope. Artificial geographical boundary lines between political units of government have no effect upon the economic laws which govern agricultural or industrial welfare; and state laws, policies or programs do not adequately meet agricultural or industrial requirements in a broad and comprehensive way.

The program must recognize that agricultural and industrial progress is made up of alternate periods of prosperity and depression; that during each of these periods there are certain economic laws the results of which are inevitable, of which a wise program or policy will take cognizance and to which it will be so adjusted that the more intelligent individual farmers shall be able to continue in the business with satisfaction to themselves and comfort for their families. From 1896 to 1920 America was in a period of increasing prices. To the ordinary income of every worker there was annually being added an extra amount which was not the direct result of his own effort, but the added effect of the rising scale of prices for everything. This movement was tremendously accelerated by the war period from 1914 to 1919 and reached its peak in 1920. Since that time we are going through the familiar and distressing effects of deflation. While there are unquestionably irregularities in the process of deflation which are causing unfair and injurious effects upon some branches of agriculture, which may possibly be amenable to legislative correction, the major course and chief results of the process are inevitable and the wise program for agricultural development must be adjusted to them.

A permanent program must, therefore, provide for alternate adjustments to periods of expansion and of retraction, of prosperity and of depression, and of rising and of falling prices. It would scarcely be appropriate to devote much time in this address to the nature of the problems which are to be met during periods of agricultural prosperity and expansion. The history of the twenty-five years immediately preceding the present depression shows how adequately American agriculture is organized to meet the needs of a growing population and increased demands for its products. The steady improvement of agricultural practises during the pre-war period, whereby a constantly decreasing farm population was able to satisfactorily feed and clothe the increasing industrial and city population, and the wonderful response of American agriculture to the wartime demands upon it are ample evidence of the adequacy of our program in periods of prosperity. Further, far-sighted men are ready with plans for better utilization of the western plains for meat production; of the cut-over

lands of the north for dairy production, and those of the south for feed and fiber production; for the reclamation of swamps for vegetable production; and for irrigation of arid lands for the production of fruit and forage; as soon as the need for expansion of agricultural production again arises. The discussion of these plans at recent meetings of agricultural college workers shows that leaders in these fields are well abreast of the times and as ready to meet emergency needs for increased production in the future as they have proved themselves to be in the past.

Nor is it necessary to discuss at length here the measures which might be taken by national or state governments or by organized groups of farmers to meet the necessities of periods of agricultural depression like the present. The wide-spread discussion in the public press is rapidly sorting out the various proposals which have been made for the improvement of the present unsatisfactory condition into those which have an adequate foundation in sound economic principles and those which are temporary political expedients of doubtful value even to those special groups of farmers whose troubles they are intended to alleviate. It is possible, of course, that some type of legislation can be devised which will give to agriculture the same sort of artificial help that the tariff gives to some forms of industry; that the guaranteed income feature of railroad rate legislation gives to transportation agencies; and that the proposed ship subsidy might give to a merchant marine. It is conceivable also that some form of organization of farmers might be devised and given legal sanction which would give to producers of food the same moral force in pushing their claims for increased wages for their work that the miners' unions and other similar organizations now possess. But these forms of remedial measures are only temporary expedients and of as doubtful utility in a permanent program for agricultural welfare as they are for the permanent welfare of the agencies which are now apparently profiting by them.

On the other hand, there are undoubtedly improvements to be made in the methods of distribution of farm products which will be to the ultimate advantage of both the producer and the consumer of these products. Undoubtedly, freight rates need adjustment in order to equalize transportation costs on agricultural products with those of the products of other industries. The present immigration restrictions which cut off a desirable labor supply for American farms certainly need modification; this would benefit both agriculture and industry. But while these matters of general moment to the agricultural group as a whole are important and are fully entitled to receive all the public attention which is being given to them, it is not my purpose to discuss these features of the agricultural program in this address. It has been my purpose to consider instead certain other matters which are not now such generally popular topics for public discussion, but which, on the other hand, may be put into actual practise by individual farmers without waiting for legislative action or for elaborate organization undertakings. It is fortunate that there are these other clear and definite ways in which individual farmers can, through their own efforts, improve their economic conditions, even in periods like the present.

It is to these possibilities for individual adjustment of the farmer's own operations, which are not now receiving as large attention in our general agricultural program as their importance justifies, that I wish to devote the remainder of this address. I am prompted to do this because of my belief that it is both the greatest advantage and the largest opportunity of farming that it is so largely within the power of the individual who follows this vocation to determine how he will meet its problems and the degree of success which he will attain in it. No labor union can ever standardize or bring to a dead level the skill, energy and efficiency of farmers. In this vocation there will always be opportunity for increased reward for increased intelligence, diligence and skill exhibited by any individual farmer.

I have already intimated that there are definite economic laws of cause and effect which, when properly recognized, may be utilized by each individual farmer in adjusting his practises to meet the changing economic situations with which he is confronted from time to time. The great difficulty which most of us have in discovering these laws is due to the fact that we fail to recognize that effects nearly always lag behind their causes in point of time. It takes time for economic forces and conditions to produce their effects, just as is the case with the physical forces and conditions with which we are surrounded. By experience, we have become accustomed to this fact in our physical surroundings and without thought or conscious care we adjust ourselves and our plans to it. As a homely example, I might cite the fact that, as I am writing this paper, the sun in his annual journey southward (as we popularly express the effect of the changing inclination of the earth's axis toward the sun in the course of the changing seasons of the year) has reached his lowest point in our southern horizon. The well-known effect of this phenomenon is to produce winter weather in the northern hemisphere. But do we Northerners expect and plan for our maximum winter conditions on December 21st? Not at all. Experience has taught us that the lag in the effect of the shortened daily period of sunshine and of the slanting

rays of the low-lying sun will exhibit its maximum effect several weeks later. So it is with all physical, social and economic cause and effect relationships. To understand and utilize such relationships we must be able to trace them correctly and to adjust our plans and operations to their inevitable operations.

The inevitable deflation of the post-war period has led to its inevitable result in a period of generally falling prices. To be sure, prices for some types of commodities have fallen more rapidly and to further depths than those of other materials. This is because of certain secondary causes which need to be carefully studied and analyzed so that their effects may be more equitably adjusted. But in the main, since the reconstruction of the post-war period is not yet fully accomplished and since world markets are not yet fully opened and world production and consumption not yet fully restored to normal conditions of steady growth, we are still in the period of general falling of price levels and the lagging effect of the principal causes for this economic situation is likely to continue for some time to come, although there are hopeful indications that the world's economic season is changing and that the warming sun of industrial prosperity is already entering upon his upward journey.

Now, these varying conditions offer to the intelligent student of them a most excellent opportunity to capitalize his superior knowledge and to profit by a better adjustment of his practises to these inevitable cause-and-effect conditions than his less intelligent competitor in the farming business can make. It is for this reason that I have felt it wise to stress in this address the possibilities and importance of individual adjustment of farming operations rather than the group adjustments which are looming up larger in public discussions just now. The following statements are, of course, not a complete presentation of the economic situation with which the individual farmer is confronted, nor anything like a complete outline of the various adjustments which he might make in his operations with advantage and profit. They are only a very brief summary of some of the more important and outstanding phases of the situation and possibilities of advantageous adjustments of the farmer's business management and operations to it.

Some of the inevitable economic effects of a period of falling prices upon the various factors of farming operations may be summarized as follows:

(1) Labor costs and taxes decline less rapidly than prices for products which the farmer has to sell; hence are relatively high.
(2) Discharge of indebtedness lags, payments of principal and interest on debts is difficult.
(3) Transportation costs and costs of retailing commodities decline more slowly than do prices.
(4) Market fluctuations are unusually large.
(5) Demand for luxuries is sometimes excellent, but generally intermittent.
(6) Products originating far from points of consumption are affected most adversely by marketing conditions.
(7) Bulky and perishable products are most affected by transportation and financing costs.

A wise program of adjustment of individual farm operations to these inevitable economic laws will include as many as possible of the following factors.

(1) Farmers should produce a larger proportion of the food products used by their own families, to avoid excessive distribution and financing cost.
(2) Retailing costs should be diminished both by more direct selling and by less wide distribution of products.
(3) Advantage should be taken of selling to deficit centers or of deficit crops.
(4) Labor costs should be reduced by the use of labor-saving machinery and by the postponement of labor-consuming improvements which yield their returns only over long-time periods, such as tile drainage, land clearing, etc.
(5) Acreages of less productive lands should be reduced, by changing cultivated fields to pasturage, or by temporarily abandoning least productive fields.
(6) Size of farms should be adjusted to a reduced supply of farm labor. Expansion in size of farms should be avoided. Large farms, requiring expensive transient labor, are not efficient in periods of depression.
(7) Acreages of high quality hays, especially legumes, should be increased, in order to provide cheap and efficient livestock feeds without transportation costs.
(8) The farmer's labor income should be supplemented by working for wages at outside work, especially near large cities.

It will at once be apparent that many of these adjustments are easiest made in those sections of the country where agriculture and industry flourish side by side; where market centers and production centers are near together. This emphasizes a principle in national policy which, while it is of importance from the standpoint of successful agriculture, is of even greater importance from the standpoint of national solidarity and prosperity. While it is a little foreign to the purpose of this address, I venture to digress far enough to say that in my judgment one of the greatest menaces to the future of our united country is the growth of sectionalism of feeling because of the geographical segregation of industries and vocations of our people.

The concentration of industries and commerce along the Atlantic seaboard and of agriculture in the Mississippi Valley and western states has already proceeded to a point where some of its baleful influences in the development of sectional feeling and prejudices are beginning to become apparent. One can not read the newspapers of the different parts of the country or discuss public matters with the residents of different sections through which he may travel without being struck with the almost complete lack of understanding and sympathy of the residents of one part of the country with the problems and views of those of other localities. Students of history can not help but note the similarity of the public controversies and lack of general sympathetic understanding of the people of the different sections of the country to the conditions which preceded our Civil war. Whatever we may think of the necessity for and glory of the other wars in which this country has participated, we can not think of the bloody Civil war between brother Americans as anything but a horrible blot upon our fair history and an event which set back the development of the southern parts of our country for a half a century.

To contemplate the possibility of sectional development of interests and prejudices to the point of another Civil war is unthinkable. Yet there are sinister possibilities in the present situation. It is clear that not only would a successful agriculture be promoted by bringing the food-producing and food-consuming populations nearer together in physical habitation and working environment; but that the intermingling of mental and social environment of workers in different vocations is a factor of solidarity and union in national life whose importance ought not to be overlooked at times such as these.

It is for these reasons that I have ventured to digress from the main thesis of this address to suggest that a national program for agricultural development should include in it a constant effort to keep both agriculture and industry and commerce as widely distributed and as closely intermingled one with the other as it is physically and economically possible to do. Such a plan will not only facilitate adjustments of labor, transportation difficulties, market distribution problems and all the other economic phases of our national welfare; but will also tend to avoid the growth of sectional differences and strifes such as are the most threatening specters of all free governments. I therefore close with a fervent repetition of the old-time New Year's prayer, "May peace prevail, and prosperity attend our ways as a united people."

R. W. THATCHER
NEW YORK STATE AGRICULTURAL EXPERIMENT STATION

SHOULD WE HAVE FACULTIES OF PUBLIC HEALTH?

Is public health a subject of enough individuality and importance to warrant its establishment as a faculty of a university? This is, in substance, the question asked by those who have the matter of advanced public health education brought to their attention for the first time. In the University of Western Ontario this question was answered in the affirmative nine years ago. The existence of a faculty of public health here (the only *faculty* of public health in America and probably in the world) is a situation so unusual that an explanation is often requested. Here is a case when an explanation constitutes a defense; and should produce conviction, leading to the establishment of similar faculties in all institutions devoted to higher education.

The questions involved are these: First, at what stage in its own development and in the development of its relationships should a given subject of human thought be recognized by separation as a faculty rather than as a department or sub-department of some other faculty? And, second, is public health now at such a stage? The answers, both in the affirmative, require some elucidation of what public health is and what its relations to higher education are.

To begin at the beginning, education, the great aim of the university, has been very variously defined, but its ultimate object is to make men not only to *feel* at home in the universe, but also to *be,* in fact, at home here. Education, since it relates to man, necessarily has the two phases, sensory and motor, which all things coming into relation with man necessarily present. The sensory phase of education is that which results in reproducing in the mind as complete a picture of the universe as possible—a working model, if you like, preferably in three—or four!—dimensions. The more nearly this ideal picture or working model within the mind corresponds with the true universe without, the more complete is the sensory education, the more *well-in-formed* is the student. The motor phase of education is that which induces the sensorially well-informed mind to study, to change, to improve, to make more perfect and more extensive the *relationships* of man to the universe. But the process of educating the individual does not consist, as, alas, it is often assumed to do, in giving first a complete sensory education leading to a B.A., and then a motor education in postgraduate courses! Such a sequence in education is a cramp upon the human race. Sensory and motor education should be reciprocal, not sequential; and should be reciprocal,

should go hand in hand, from the kindergarten up. It is not the good fortune of every educator to see true education thus as a whole. Many a specialist, of perfect education in his own field, is like a microscope in sacrificing to intensity of penetration all breadth of view; or like a telescope in revealing the far-off stars but missing the intimate bacteria completely. We have also those educators to whom education is chiefly sensory, and those to whom it is chiefly motor. But all real educators must grant that in the end the goal of a really good education is to *appreciate* fully and to *act* wisely on the main facts of life. Now the central fact of all human life is this —that man is part of nature, not something different from it; that man is a true product of the planetary soil and air, not an afterthought or an accident. This central if very elementary conception, when taken together with all that necessarily flows from it, constitutes the nucleus of true education in its best sense.

Sensory education, then, is receptive, pictorial, contemplative, analytic; it deals with and records things as they are, the status in which man finds himself. Motor education is aggressive, constructive, progressive, synthetic; it deals with the relationships of man to the universe; *i.e.,* with his relations to that status in which he finds himself. Relationships, where life is concerned, are always dynamic, not static; motor, not sensory. While sensory and motor represent contrasting types of education, they are not in any sense antagonistic. On the contrary, they are correlatives of, and complementary to, each other. Some day, when the purpose and methods of educations are better understood, these two phases of training will be treated always as one, as much so as any two halves of an apple.

The relationships of man to the universe fall by general consent into four groups, roughly outlined and overlapping, yet more or less useful in grasping the situation; these are the physical, the mental, the moral and the spiritual. Oldest of these, it appears, and most developed in the mind of man, most influential so far in shaping his conceptions are those relationships usually grouped as spiritual. No primitive people is too primitive for the development of this group. Theology, the subject that deals with the relationships of man to his spirit world (if we include in it conceptions and studies of all spiritual imaginings, of man's relationships to gods and devils, to spirits of all kinds), is the oldest subject of human thought; and in institutions of higher education constitutes the oldest established faculty—indeed theology is academically the father and mother of all other faculties. Next, but a long way after, and far more concrete and definite, come moral relationships, the relationships of man to other men, ethics. Far down the line, in quite recent centuries, mental development, still more concrete, still nearer man himself, formulated the great idea of science; that man might through his own mind achieve invaluable improvements in his understanding of and his relationships with the universe as a whole, not merely with spirits or with other men. Yet even in science is illustrated man's reluctance to study the things under his nose, his tendency to wander afar in his researches; for human science began concrete studies of nature with astronomy, the most remote of all physical relationships! Sociology, being the study of intimate social relations with other men, and including physical relations, not merely moral, is of very recent development. But it has been reserved for the twentieth century to get down to real "brass tacks," to conceive of the study of man's own individual physical abilities, his own individual physical relationships, as of the first importance; and this is what is known as public health.

It was anthropomorphism in its primeval form that dictated the old spiritistic attitude and minimized the physical or rather ignored it. Like most such primitive conceptions, anthropomorphism is a mirror picture of the truth; and, like a mirror picture, requires inversion to make it agree with the facts. Anthropomorphism is well enough, but only if we invert it, *i.e.,* only if we appreciate that the universe is not modelled on man, but man on the universe; that he is indeed an outgrowth of it, bearing its pattern, a subject of its laws in every feature.

To this anthropomorphic, illogical and inverted order of man's consideration of his relationships to the universe is due the lateness of his recognition of public health, a twentieth century matter. Beginning with the random imaginings of his scarcely opened mind, man produced a vast variety of beliefs supposed to indicate his relationships to spirits; he sacrificed all to these internally-derived mental images, and went gladly to the stake for conceptions that he could not check up with external realities, did not think of as having any relationships to anything outside his own mind. So far as externals were considered at all, they were made to fit with and into his scheme of internally-derived mental images rather than the reverse. Next, morals gave man something more tangible, more mundane, nearer home, more concrete, more easy to demonstrate, yet still very largely debatable, still a matter of going to the stake for his beliefs rather than of calm demonstrations of certain realities as parts of the universe. Then, still more definite, still more concrete, still less debatable, still more demonstrable, mental education appeared. Last of all has come the study of physical relationships, which we now see has grown out of the preceding development of education; and which since probably all the others depend upon it, is *the* fundamental study.

Had it developed in proper sequence, it would have preceded the others. We must now begin all over again, to rearrange the existing sequence in proper order; for the modern recognition of man's own part in the universe, as developed by education, has completely inverted the old order of the different phases, spiritual, moral, mental, physical; they may now be placed in the natural order in which they properly stand to each other. Instead of building from the roof down, the twentieth century would build from the ground up; placing the physical first, the spiritual last, instead of the converse; in this, at least, agreeing with St. Paul!

But have not the ultimate physical relationships of man been heretofore studied? True, medicine deals with the physical relationships of man and as a department of human thought it has been accepted as of sufficient importance to constitute a university faculty for hundreds of years. But medicine, a very crude conception in its earlier days, dealt then and deals now only with a part of the physical adjustment of man to the universe; that is, with that partial phase which seeks to readjust only those who are already so out of proper relationship physically that actual pain and disability develop. Since this very partial view of physical relationships is worthy of a separate faculty and has been so considered even while it existed only in the crudest, most elementary forms, surely public health which deals with *all* physical relationships, for *every* human being, to *prevent* such maladjustments, is still more so entitled.

It is difficult for laymen, and sometimes even for otherwise well-informed professional students of medical science, to see public health and medicine in perspective. The former is historically an outgrowth of the latter, but yet it includes the latter and also a great deal more. Public health seeks now to place a knowledge of medicine in its proper relation to public needs. It undertakes to ascertain the remoter causes of disease and to *prevent* these "ills that flesh is heir to," instead of merely to institute curative treatment after disease has already become established. Medicine is quite invaluable to the sick, but public health is invaluable to the well also.

The reasons for separating out any subject or group of subjects to constitute a separate faculty would appear, on study of existing faculties to be: First, academic, *i.e.*, based on obvious relationships of the subject or subjects to the various university curricula; second, administrative, *i.e.*, based on university staff and student affiliations; and third, practical, *i.e.*, based on the requirements of the outside world, and the preparation of students for its service. Thus, a faculty of law exists for academic reasons, because many of its subjects are apart from those of other courses; for administrative reasons, because its staff and its students are necessarily distinct from other groups; and for practical reasons, because it prepares its students for a special service in the world. A faculty of science exists for similar, yet in some cases converse reasons; academically, because it enters into several other courses and can not be assigned to any one course; administratively, because, while its staff is a unit, it serves several groups of students and can not be assigned to any one group; and practically, because it prepares in itself students for many special sorts of service in the world, of a character dissimilar from that provided by other faculties. These reasons have resulted in the formation of a variety of faculties in various universities, each usually distinguished by a special form of degree or other qualification conferred upon its own particular graduates.

The outstanding reasons for the formation of a faculty, then, are to simplify the system and facilities of the internal operation of the university, and to preserve useful relationships with the outside world. In all these, public health qualifies, as will now be shown.

That the recognition of public health as a group-study independent of medicine has been granted elsewhere than at the University of Western Ontario although not so far as a faculty is too well known for detailed recapitulation. The University of Pennsylvania first, many years ago, established an Institute of Public Health. Now Johns Hopkins and Harvard, under Welch and Rosenau, respectively, have independent schools of public health, fostered by large gifts from the Rockefeller Institute, which latter has with large vision and practical foresight promoted public health in these academic as well as in great practical enterprises. This year, old London, under Rockefeller stimulation, has opened or is about to open, an independent school of public health. The courses offered vary from one year, for postgraduates in medicine offered by many universities in Great Britain, to four years for non-medical candidates, offered by many universities in the United States. The University of Western Ontario has merely gone one step further; has already made that which is the next logical step for all; has constituted public health a faculty, on the same basis as any other faculty, and has thus given to public health full twentieth century recognition of its proper position.

There are certain specific subjects, peculiar to public health and not taught in medical curricula because they are not of practical interest to medical men. These at most are merely referred to incidentally in medical courses except in the special short public health course which is included in most medical courses. Notably these subjects are, first, the reac-

tions of the healthy body as distinguished from the diseased. True, incidentally to the teaching of disease, the normal is mentioned in purely medical courses—but that is all. Again, epidemiology, dealing with the causes of disease outside the body, with those remoter causes which must be studied and appreciated in every detail to attain the prevention of disease, is all but ignored in medical curricula, for the medical interest lies in the cause *after,* not before, it enters the body; and then only when it gives therein appreciable symptoms. Again, vital statistics are almost wholly untouched in medical curricula, again because the interest is in disease, not in health; in the disease of the already sick individual, seeking relief, not in his social, economic, or other public health relationships to disease. Almost the only interest of public health closely allied with the medical curriculum is that of diagnosis; and even here the high emphasis of the medical course lies in diagnosis for treatment, not in diagnosis as part of sociology. In physics, geology, chemistry, in bacteriology, parasitology, in every one of the subjects of a full public health course, not only is each subject given time almost as great, sometimes greater than the whole time given in the ordinary medical public health course to the public health applications of all these subjects put together, but again, the material and the emphasis given for professional public health purposes differ from the material and the emphasis given in the same subjects when taught as a brief part of the medical course proper.

Academically then public health has a place in education peculiarly its own, with an individual curriculum composed of special certain phases of all other sciences and many arts; administratively, its staff and its students constitute a separate unit, requiring certain of these sciences as taught by other faculties but also having certain subjects of its own not dealt with by the others; and serving other faculties with these. Practically, public health prepares its special students for a special field of services which is in continually growing demand—a profession as distinct in its services to mankind as are the professions of theology, agriculture, medicine, law, engineering, dentistry, mining or any other. That public health should continue to be merely a 45 hour course in a medical curriculum, as it is to-day in many universities, is as unreasonable to-day as it would be to place mathematics as a department of engineering or of physics; to make law a division of ethics; or to make chemistry a detail of agriculture. Such classifications might be made—might even be ably defended—but classifications to be of highest value must correspond with the greatest number of relationships, and it is a broad useful form of classification which makes public health, on academic, administrative and practical grounds, an independent faculty, manned and equipped for its peculiar researches, teachings and applications to the progress of the whole race.

Summary: *Public health is the science and art of conscious physical adjustment between man and his surroundings in the universe.* The modern conception of man as a product of and a part of nature brings the subject of man's individual physical adjustments with his immediate surroundings into its proper place as *the* fundamental study—*the* basis of every form of education. Hence, public health is not only eligible for a position as an independent faculty in any university but is as definitely entitled to such a place as any of those now recognized. It is futile to consider the ordinary 45 hour course in public health, furnished as an incident in the ordinary 4000 to 5000 hour medical course, as more than a smattering, offered to medical students alone, of the 900 to 4500 hour courses in public health offered to professional public health students.

H. W. HILL

UNIVERSITY OF WESTERN ONTARIO,
LONDON, CANADA

SCIENTIFIC EVENTS

THE EQUADOR-COLOMBIA EARTHQUAKE

THE following letter to the Secretary of State, Washington, has been forwarded by the Department of State to the Smithsonian Institution:

Referring to my telegram No. 30, of December 20, 12 noon (1923), I have the honor to report more fully concerning the earthquakes which have occurred during December in this Republic.

The seat of the first and most severe shocks was along the Equadorean-Colombian frontier, the damage in this country being principally confined to a relatively small area in the Department of Narino situated near the town of Ipiales and Tulcan. The first earthquake was felt on December 13, and was followed almost daily up to December 20 by other severe earth tremors. As a result the villages of Cumbal, Carlosama, Aldana and Chiles appear to have been totally destroyed and considerable damage done in the towns of Tuquerres and Ipiales. Nevertheless, it is a most inexplicable circumstance that even today no exact data concerning the loss of life and property is available in Bogota. Neither the government nor the Colombian Red Cross is in possession of reliable statistics. As nearly as I can ascertain, however, the more conservative estimates place the dead at two, or possibly three hundred, and the homeless in the neighborhood of 20,000 persons. The property loss, from a monetary standpoint, is probably very small as the inhabitants of the district are of humble mode of existence. Aid, though slow in reaching the stricken area, in part due to bad means of communication, at length reached the population, who are said to have been suffering greatly from cold on account of the high altitude. As a

gauge of the extent of the catastrophe, the appropriation of the National Government of $15,000 for relief is enlightening as well as the subscriptions of various organizations and private individuals, none of which was large.

Since the initial damage in Narino, other portions of Colombia have been visited by the earth disturbance. About five in the morning of December 22, a severe shock was registered throughout central Colombia, including Bogota. No appreciable damage was done in the capital, but Gachala, Gacheta and Ubala, towns some forty miles northeast of Bogota, are reported largely demolished and much damage done in Medina. Strange to say, only seven persons were killed. Communication with this area was impeded by the obliteration of the Medina road and the destruction of telegraph lines. Slighter shocks followed up to the twenty-sixth of the month completing the damage. It is probable that the suffering is slight in this locality as the climate is warm.

Immediately upon learning of the full extent of the difficulty in Narino, I addressed a note of sympathy to the government. The American colony in Bogota followed generously with a subscription for the sufferers which was turned over to the Colombian Red Cross. To this testimony of friendship was added the message of condolence contained in the department's telegraphic instruction No. 35 of December 24, 4 p. m., which was immediately made known to the Ministry for Foreign Affairs. The generous offer of tentative assistance, proffered by the American Red Cross to the Colombian Red Cross, came as a happy final demonstration of the interest felt in the United States for the afflicted here.

SAMUEL H. PILES

AGRICULTURE IN THE TROPICS

THE Governor of Trinidad, Sir Samuel Wilson, laid the foundation-stone of the buildings and laboratories of the Imperial College of Tropical Agriculture at St. Augustine on January 14.

The London *Times* writes:

It is five years since Lord Milner, as Colonial Secretary, appointed a committee to consider the establishment of such an institution. After two years of careful inquiry the committee submitted its recommendations, and a scheme was drawn up to provide for the foundation of the college, which was opened in 1922. The first intention was to limit the scope of its activities to the West Indies themselves, and its actual title was "The West Indian Agricultural College." Gradually, however, its real value to the tropical dependencies of the Empire was realized, and last year it was decided to place it on a broad imperial basis.

Already there is evidence of the desire upon the part of the college authorities to lay their resources at the disposal of the Empire, and in the first number of *Tropical Agriculture*, the official journal of the college, there are instructive notes upon agricultural development not only in the West Indies, but in Ceylon, Sierra Leone, Gambia, Tanganyika and the Sudan. Four post-graduate students have already been sent to the college by the Empire Cotton Growing Corporation for special research work in genetics and plant breeding. Eighteen students are now taking the three-year course necessary to gain the diploma of the college.

Arrangements are in progress for the early erection of a complete sugar factory designed for teaching and experimental purposes. The machinery for this has been presented by the leading manufacturers of sugar machinery in the United Kingdom. The factory will be of a size sufficient to manufacture sugar on a small commercial scale and will, to a large extent, be operated by the students.

The appointments of the college are controlled by a governing body, on which Cambridge University is represented by Sir Arthur Shipley; the Secretary of State for the Colonies by Sir David Prain and Mr. E. R. Darnley; Glasgow University by Professor F. C. Bower; the Royal Botanic Gardens, Kew, by Captain A. W. Hill; and the Imperial College of Science and Technology by Professor J. B. Farmer. The principal is Sir Francis Watts, K.C.M.G., D.Sc.

Incorporated with the college is the Imperial Department of Agriculture. In this department special attention will be paid to research under the guidance of a staff which includes professors of zoology and entomology, mycology and bacteriology, botany, chemistry, agronomy and economics, and a sugar technologist.

DATA FOR THE INTERNATIONAL CRITICAL TABLES

THE editorial board of International Critical Tables will appreciate receiving from scientific investigators any numerical data which they are able and willing to furnish, which have not been published prior to January 1, 1924. All data are desired which characterize the behavior of any definite material, substance or system. For the purpose of this request, such data will be divided into two classes, as follows: Class I: data which constitute the only information of the kind available; Class II: data which, in the opinion of the investigator, substantiate, extend or improve upon existing information of the same kind.

In connection with data belonging to both classes, the following information should be given: (a) an exact definition of the material, substance or system to which the data apply; (b) the investigator's estimate of the accuracy of the values; (c) the name of the investigator or investigators responsible for the measurements; (d) the laboratory in which the investigations were carried out; (e) a brief statement of the experimental method used; (f) an exact statement of the units in which the data are expressed; and (g) any other supplementary information necessary for the complete characterization of the data.

For the data belonging to class II, such additional

data should be furnished as will enable the expert in charge of this class of data to evaluate critically the new in comparison with the older data. Manuscript or corrected page proofs should be furnished where possible.

Any data belonging to class I, received prior to January 1, 1925, and any data belonging to class II, received before July 1, 1924, will be in time for inclusion in International Critical Tables, and the source of all data so included will be indicated by "Private Communication from, etc." or in such other manner as the author may prefer; unless a literature reference becomes available before going to press. Data determined by members of the staff of a research laboratory should be forwarded through the director of the laboratory. All data should be sent to International Critical Tables, National Research Council, Washington, D. C.

MARTIN JOHNSON AFRICAN CORPORATION

PRESIDENT HENRY FAIRFIELD OSBORN of the American Museum of Natural History has announced the ratification by the Board of Trustees of an agreement between the museum and the Martin Johnson African Corporation. The directors of this corporation are Daniel E. Pomeroy, A. Perry Osborn, F. Trubee Davison, Carl E. Akeley, John H. Prentice, H. Morton Merriman, Lewis L. Delafield, Jr., Dexter C. Hawkins and Robert E. Lee, all of whom are well known for their public activities.

President Osborn stated that, according to the terms of the agreement, Mr. Johnson would direct his energies and efforts to secure a truthful photographic portrayal of all phases of African life. In order that the record which he obtains become a correct and dependable chronicle of the peoples and animal life still existent on that continent, he has placed himself and his work under the direct scientific supervision of the authorities of the American museum, which will become the permanent depository of all the motion picture films, negatives and other physical material which Mr. Johnson secures during the five years of which the expedition will continue.

The acquirement of these records, together with all other photographic negatives and films which Mr. Johnson has secured during his twenty-six years of travel in the South Seas, Australia, Egypt, Africa and other places, and which he has recently donated to the museum, will form an unprecedented series of scientific and educational value. Mr. Johnson, together with Mrs. Johnson, left for Africa in December, taking with them one of the most complete photographic outfits that ever went into the field for a similar undertaking. Mr. Johnson is an expert photographer and is as much at home in the laboratory as he is behind the camera. The photographic experience which he previously acquired in the tropics gives him a distinct knowledge of the difficult twists and quirks necessary to secure good results, and promises a quality of production unexcelled in the history of motion-picture photography.

EMINENT AMERICAN CHEMISTS[1]

FROM time to time there have come to us requests for sources of portraits of eminent American chemists prepared for framing and suitable for decorating laboratories, lecture rooms, and the halls of educational institutions. Diligent search having shown that very few Americans had been included in such collections of portraits as had been made by publishers, we persuaded our associate editor to undertake the preparation of such a collection, calling upon a number of men to assist in compiling a list of those to be included in the first series. This work has been completed and, if advance subscriptions warrant, a set of thirty-three portraits, beautifully done on the best grade of paper, will be available in a loose-leaf binder, these portraits being interleaved with short sketches of the work of each of the subjects. The portraits themselves are 4½x6½ inches on sheets 8½x10 inches. Announcements will be made soon as to prices and other details. We give below the list of the men included in this set and believe that if a larger number of people become interested in the personalities which have so greatly contributed to the advancement of chemistry, a historical and cultural background will be established which can not fail to make our science still more attractive.

Baekeland, L. H.	Langmuir, Irving
Bancroft, W. D.	Lewis, G. N.
Boltwood, B. B.	Mallett, J. W.
Booth, J. C.	Morley, E. W.
Chandler, C. F.	Noyes, A. A.
Chittenden, Russell H.	Noyes, W. A.
Clarke, F. W.	Priestley, Joseph
Cottrell, F. G.	Remsen, Ira
Cooke, Josiah P.	Richards, T. W.
Franklin, E. C.	Rumford, Count
Gibbs, J. Willard	Sillimar, Benjamin, the Elder
Gibbs, Wolcott	Smith, Edgar Fahs
Gomberg, Moses	Smith, J. Lawrence
Hare, Robert	Stieglitz, Julius
Hillebrand, W. F.	Van Slyke, Donald D.
Hunt, T. Sterry	Whitney, W. R.
	Wiley, H. W.

SCIENTIFIC NOTES AND NEWS

DR. FREDERIC A. LUCAS, after serving for twelve years as director of the American Museum of Natural History, has become honorary director, and will act

[1] From *Industrial and Engineering Chemistry*.

in an advisory capacity. Dr. Lucas will reach his seventy-second birthday on March 25. Mr. George H. Sherwood is promoted to the post of acting director for a term of two years.

DR. WILLIAM W. KEEN, emeritus professor of surgery in Jefferson Medical College, Philadelphia, who has recently returned from a scientific mission to Europe, celebrated his eighty-seventh birthday on January 19.

THE motion picture industry will tender a testimonial to "the father of the motion picture," Thomas A. Edison, on the occasion of his seventy-seventh birthday on February 15, at the Ritz-Carlton Hotel. It will take the form of a luncheon, at which Mr. Will Hays will act as toastmaster.

DRURY COLLEGE, on the occasion of its fiftieth anniversary, conferred an honorary doctorate on Professor B. F. Finkel, of the department of mathematics, founder of the *Journal* of the American Mathematical Association.

DR. D. J. HISSINK, director of the Agricultural Experimental Station (Section for Soil Science), Groningen, Holland, is the recipient of the degree Dr. oec. publ., *honoris causa,* from the University of Munich, for his outstanding researches in the field of soil science.

THE Symons Gold Medal of the Royal Meteorological Society was presented at the annual general meeting of the society on January 16, to Dr. Takematsu O-Kada, director of the Central Meteorological Observatory at Tokyo.

A COMPLIMENTARY dinner was given to Dr. Adolph Koenig at the University Club, Pittsburgh, on January 19, by colleagues and friends. Dr. Koenig, who conducted the *Pittsburgh Medical Journal* which merged with the state medical journal, was for eighteen years a member of the state board of medical examiners and was formerly president of the state medical society.

A DINNER was tendered to Sir John Bland-Sutton on January 24 to mark the occasion of his election to the presidency of the Royal College of Surgeons of England.

AT a conference on the standardization of clinical thermometers, held on January 30 at the U. S. Bureau of Standards, Dr. Lyman J. Briggs represented the American Association for the Advancement of Science.

AT the annual meeting of the American Association for the Advancement of Agricultural Teaching at Chicago the following were elected officers for the coming year: E. E. Gallup, *president* (Michigan); H. F. Cotterman, *vice-president* (Maryland); Dean C. H. Winkler, *secy-treas.* (Texas). The following, together with the officers listed above, constitute the executive committee: A. W. Nolan (Illinois), C. E. Myers (Pennsylvania), Dean W. C. Coffey (Minnesota).

PHILIP S. SMITH, of the Geological Survey, has returned to the Alaska branch, and will undertake for that branch and the Navy Department the examination of Naval Petroleum Reserve No. 4, Alaska. Julian D. Sears has been designated administrative geologist to fill the position relinquished by Mr. Smith.

WALTER W. SCOTT, deputy supervisor of the Department of the Interior for oil and gas operations in the Gulf Coast district, has been transferred by the Bureau of Mines to a similar position in the Rocky Mountain district, with headquarters at Casper, Wyoming. Mr. Scott assumes the position made vacant by the resignation of Charles E. Beecher, who has become associated with the Empire Gas and Fuel Company, with headquarters at Bartlesville, Oklahoma.

H. A. C. JENISON has resigned from the Geological Survey to accept a position as mining engineer with the Senate Commission on Gold and Silver Inquiry.

HARDEN F. TAYLOR has resigned as assistant in charge of the Division of Fishery Industries, U. S. Bureau of Fisheries, Washington, D. C., to become director of the Technical and Research Laboratory, Atlantic Coast Fisheries Company, New York, N. Y.

PROFESSOR S. J. ALLEN, head of the department of experimental physics of the graduate school of the University of Cincinnati, has been appointed special adviser for research work in terrestrial magnetism by the Carnegie Institution. Professor Allen will leave shortly for England, to pursue his research work at Cambridge.

DR. WILLARD ROUSE JILLSON has been reappointed director and state geologist of the Kentucky Geological Survey for a four-year term beginning April 1, 1924, by the new governor, the Honorable William J. Fields. Dr. Jillson has served under four administrations. The Kentucky Geological Survey has been included in the proposed Kentucky $75,000,000 bond issue to the extent of $400,000 for the completion of the topographic base map of the state. The bond issue is now being acted upon by the legislature and if submitted to the people will be voted upon during the autumn.

PROFESSOR E. A. KHOLODOVSKY, assistant professor of mathematics at the Polytechnic Institute of Petrograd, has been appointed assistant in the Lick Observatory.

PROFESSOR F. H. VOSE, head of the department of mechanical engineering at the Case School of Applied Science, has recently accepted additional duties as

head of a new department of the George T. Trundle, Jr., Engineering Co., of Cleveland, to be devoted to problems of power and fuel.

DEAN D. W. WORKING, of the Colorado Agricultural College, has been commissioned by the State Department of Agriculture to gather and compile information for an agricultural history of Colorado which is to be the contribution of the college to the state's semi-centennial celebration in 1926.

LADY CONSTANCE BUTLER has been appointed director of the roentgen-ray department at St. Andrew's Hospital, London.

WE learn from *Nature* that Commander E. A. Martin has been elected secretary of the South-Eastern Union of Scientific Societies in succession to Mr. H. Norman Gray, who has resigned after many years of office. Commander Martin will be assisted in his duties by Mr. R. W. Strickland.

THE resignation on account of ill health of the chief of the public health service in Spain, Dr. Martin Salazar, has been accepted, and his assistant, Dr. F. Murillo v Palacios, has been appointed his successor.

DR. WILBUR A. SAWYER, who for the last five years has been in Australia in connection with the International Health Board, will return to the United States this spring. While in Australia Dr. Sawyer was instrumental in organizing the Public Health Association of Australasia and served as editor of the *Health Forum,* published quarterly by that association.

HENRY M. AMI has returned from France to Ottawa and has resumed his work in paleontology and chronological geology. During the last six months he served with the Canadian Government mission on Natural Resources to France.

DR. J. J. SEDERHOLM, director of the Geological Survey of Finland, invites geologists interested in the problems of Pre-Cambrian rocks to visit the islands and coast near Åbo in south-west Finland for an excursion of about three days' duration in the early part of June.

LUDLOW GRISCOM, assistant curator of ornithology at the American Museum of Natural History, sailed on February 5 on the steamer *Cristobal* for Veragua, western Panama. With him went three assistants, Mr. Rudyerd Boulton, of the University of Pittsburgh; Mr. J. Manson Valentine, of the Peabody Museum, Yale University, and Mr. George Albert Seaman. The expedition is primarily ornithological, and hopes to reach the subtropical zone in the unexplored mountains of the interior to determine its extent and whether there is a break between it and the mountains of Chiriqui further west. Somewhere in Veragua the Costa Rican Highland fauna and the lowland tropical fauna of eastern Panama meet, but the barrier separating them is unknown.

As the result of an agreement recently effected between the British Home Office and the Department of the Interior for the exchange of technical information as to means of preventing mine accidents and the promotion of mine-safety conditions, Dr. R. V. Wheeler, professor of fuel technology at Sheffield University and director of the Eskmeals Testing Station, Cumberland, England, and W. R. Chapman, scientific assistant to Dr. Wheeler, are due to arrive in New York about February 16, for the purpose of observing the progress of research work in the United States. Henry Walker, deputy chief inspector of mines for the British government, will arrive in New York about February 23. Mr. Chapman will be detailed to the Pittsburgh Experiment Station of the Bureau of Mines for an indefinite period, for the purpose of studying American methods of research. The visiting technologists, after attending the meeting of the American Institute of Mining and Metallurgical Engineers in New York, will visit Washington, Pittsburgh, Chicago, Schenectady and other cities, where inspections of various research laboratories and industrial plants will be made. The experimental coal mine of the Bureau of Mines, near Pittsburgh, and certain of the larger bituminous coal mines in Illinois will be visited. The party will be escorted by George S. Rice, chief mining engineer of the Bureau of Mines, who recently returned from a protracted study of European mining conditions, and at whose suggestion the agreement for an exchange of technical information was effected.

THE eighth expedition of the Department of Tropical Research of the New York Zoological Society left New York on February 11 on the steamship *Mayuro* for Georgetown, British Guiana. The ultimate destination is the society's tropical research station which has been maintained for a number of years at Kartabo, in the heart of the jungles. The staff of the expedition is as follows: William Beebe, director; Alfred Emerson, assistant director; John Tee-Van, research assistant and cinematographer; William Merriam, assistant in field work; Harold Tappin, assistant in entomology; Herman Rogers, assistant in photography; Harry Hoffman, artist; Isabel Cooper, scientific artist; Helen Tee-Van, assistant scientific artist; Ruth Rose, historian and technicist, and Katherine Rogers, assistant in microscopy.

DR. ALFRED M. TOZZER, professor of anthropology at Harvard University, will give a series of six Lowell lectures during February on "Social Origins and Social Communities."

DR. CHARLES WARDELL STILES, chief of the division of zoology of the Hygienic Laboratory, Washington, D. C., gave two lectures on the "Methods of fecal disposal in relation to distribution of animal parasites of man," to the Journal Club of the department of medical zoology of the School of Hygiene and Public Health of the Johns Hopkins University, on January 25 and February 1.

DR. MADISON BENTLEY, of the department of psychology of the University of Illinois, will address the Kansas College Chapter of Sigma Xi on February 15 on "Science and magic." Tentative plans have been made by the members for a banquet in the evening, at which Dr. Bentley will be the guest of honor. After this banquet there will be an open meeting of the chapter in the recreation center at which Dr. Bentley will speak on "Spatial Orientation of Man and Other Animals."

PROFESSOR S. I. BAILEY, senior member of the staff of the Harvard College Observatory and Phillips professor of astronomy since 1912, who has been in charge of the station at Arequipa, Peru, for the past two years, spoke on January 31 at the observatory on "Harvard observatories in Chile and Peru."

FOLLOWING an all-day session on March 19, the council of the American Association of Mechanical Engineers will attend a dinner meeting of the Grand Rapids Engineering Society, at which Arthur H. Blanchard, professor of highway engineering and highway transport at the University of Michigan, will speak on the "Interrelationship of highway design and highway transport." President Low and other members of council will make short speeches after Professor Blanchard's address.

DR. H. FOSTER BAIN, director of the U. S. Bureau of Mines, gave an address before the engineering students of the Carnegie Institute of Technology, Pittsburgh, Pa., on January 22.

DR. MORTON PRINCE, of Boston, will give a short course of lectures at the University of Cambridge on "Subconscious phenomena," commencing on February 12.

PROFESSOR E. C. WILLIAMS, the recently elected Ramsay professor at University College, London, gave, on January 17, his inaugural lecture on "The Aims and Future Work of the Ramsay Memorial Laboratory of Chemical Engineering."

PROFESSOR HIRAM MILLS PERKINS, donor of the new observatory of Ohio Wesleyan University and for fifty years a member of the university faculty, died at his home in Delaware on January 25 at the age of ninety years.

PROFESSOR MELVIN ERNEST SHERWIN, of the College of Agriculture and Engineering at Raleigh, N. C., for thirteen years head of the department of soils, died on January 5.

THE Third Pan-American Scientific Congress will meet in Lima, Peru, next November. This will be the first meeting since the war and a large attendance is expected from not only all parts of Latin America, but from the United States and Canada. The leading scientific associations will send delegates and the United States will also be officially represented. The two previous Pan-American Scientific Congresses met in Santiago, Chile, in 1908 and in Washington in 1915. The last congress was divided into nine sections and practically all branches of science were represented in the discussions. The Pan-American Union is assisting the Peruvian government in circulating information as to the congress among scientific men in the United States.

To assist in the arrangements for the annual meeting of the British Association for the Advancement of Science which will be held in Toronto from August 6 to 13, Oscar J. R. Howarth, the organizing secretary of the association, visited that city, returning to England on February 9. Thirteen sectional committees have been formed in Toronto to collaborate with the organizing committees in London. In addition, district committees have been organized in other cities. The Dominion Government has made a grant of $35,000 and the provincial government of $25,000 toward the expenses of the meeting.

THE Fourth International Conference of Soil Science is to be held in Rome, Italy, in May, 1924. The American delegates to the conference include J. G. Lipman, of Rutgers College and the New Jersey Experiment Stations, who is chairman of the Committee on Microbiology for North and South America and Asia; C. F. Marbut, Bureau of Soils, United States Department of Agriculture; A. G. McCall, University of Maryland; Arao Itano, Massachusetts Agricultural College; Augusto Bonazzi, Ohio Experiment Station; S. A. Waksman, R. V. Allison and R. M. Barnette, New Jersey Experiment Stations.

THE trustees of the American Medical Association have made an appropriation of $2,000 to further promising research in problems relating to scientific medicine and of practical interest to the medical profession, which otherwise could not be carried on to completion. Applications for small grants should be sent to the committee on scientific research, American Medical Association, 535 North Dearborn Street, Chicago, before March 10, when action will be taken on the applications at hand.

THE first awards from the Benjamin Franklin Fund, which was established in 1759, are announced. The awards are as follows:

MAJOR AWARD.—P. W. Banning, of Los Angeles, on published work, "Mental and spiritual healing; all schools and methods; a text-book for physicians and metaphysicians." £2,500 scholarship.

AWARD.—C. P. Steinmetz, of Schenectady, privately published treatise, "The nervous system as a conductor of electrical energy." £1,000 and republication of treatise.

MINOR AWARD.—Fusakichi Omori, of Tokyo, unpublished treatise, "The rotary knife in surgery." £500 and publication of treatise.

Benjamin Franklin spent much time in England from 1757 to 1762 representing the American Colonies. While there he placed £100 in the hands of members of the Society of Friends as a trust, to be invested with accumulations, for not less than 150 years. Thereafter, at the discretion of the trustees, awards were to be made from time to time for the most valuable contributions to science considered by them, either manuscript or published, on the subject of cures, but particularly in relation to surgery, the nervous system, and the part "mind treating" has in the recovery and preservation of health.

A FUND is being collected for an endowment in honor of Angelo Mosso, emeritus professor of physiology at Turin, founder of the Monte Rosa laboratory for research on effect of altitude. The endowment is to benefit students and war orphans.

AN appeal was made last summer for funds to establish in London a Ross Institute for Tropical Diseases in commemoration of the twenty-fifth anniversary of Sir Ronald Ross's work on malaria. The executive committee has now the opportunity of acquiring suitable premises which, with the necessary alterations, would make a permanent memorial of the kind required. The cost will be £30,000. Contributions should be sent to the hon. treasurer, addressed to the Institute's temporary offices, 56, Queen Anne-street, London, W.1, or to the manager of the Westminster Bank, 1, Stratford-place, London, W.1.

As has been noted here *Discovery*, the English journal of popular science, has been revived through the support of a guarantor who prefers to remain anonymous, and the cooperation of an educational trust with which he is associated. Mr. R. J. V. Pulvertaft succeeds Mr. E. J. Liveing as editor.

A NEW journal devoted to the interests of teachers of chemistry has been founded by the Section of Chemical Education of the American Chemical Society. This journal is to be known as the *Journal of Chemical Education*, the first number of which has been mailed. It has been made possible by the cooperation of members of this section under the active leadership of Neil E. Gordon, its secretary. Dr. Gordon, the editor-in-chief, will be assisted by the following departmental editors: H. C. Sherman, Columbia University, New York, N. Y. (*Undergraduate Chemistry*); William McPherson, Ohio State University, Columbus, Ohio (*Graduate Chemistry*); R. E. Rose, duPont de Nemours & Co., Wilmington, Del. (*Industrial Chemistry*); Wilhelm Segerblom, Phillips Exeter Academy, Exeter, N. H. (*High School Chemistry*). Contributing editors from about thirty states are aiding in the project.

UNIVERSITY AND EDUCATIONAL NOTES

THE laboratory building on the campus of the California Institute of Technology at Pasadena has been completed and the apparatus is being installed. Four 250,000-volt transformers, with a capacity of 1,000 kw., are being set up. This million-volt laboratory, the first to be established in the West, was made possible through the cooperative effort of the Southern California Edison Company and the California Institute of Technology. The power company furnished the building and the school is furnishing the equipment. The research work will be carried on under the direction of Dr. Robert A. Millikan.

THE home minister of Japan has notified the Rockefeller Institute that they would prefer a hygiene and sanitation laboratory to be erected at a cost of 5,000,000 yen ($2,500,000) following the offer of the Rockefeller Institute of New York to make a present of some scientific institution to that country. A committee of establishment of the Rockefeller Oriental Hygiene and Sanitation Laboratory will be formed on the arrival of the Rockefeller mission from the United States. On completion of the laboratory, St. Luke's Hospital will become affiliated with it and the government will be asked to bear the expenses of maintaining both institutions.

DR. F. B. KILMER, of New Brunswick, N. J., has established a research fellowship in pharmaceutical botany at the Philadelphia College of Pharmacy and Science.

PROFESSOR J. B. SHAW, department of ceramics, Alfred University, Alfred, N. Y., has resigned to become head of the new department of ceramic engineering established at the Pennsylvania State College, State College, Pa.

PROFESSOR W. A. HAMILTON, who resigned his position at Beloit College because of the manner of dismissal of one of his colleagues, has been appointed lecturer in mathematics at the University of Wisconsin for the coming year.

PROFESSOR P. J. DANIELL, of the Rice Institute, has been appointed to the Town Trust chair of mathematics at the University of Sheffield.

DISCUSSION AND CORRESPONDENCE

THE TERMS ANODE AND CATHODE

THERE is a common statement about these two terms which is to be found in most text-books and which is frequently retailed by lecturers upon electrical and electrochemical subjects to the effect that the word anode, derived from the Greek terms for "up" and "a way," indicates the way "up into the cell" and that the word cathode, coined similarly from "down" and "a way," denotes the way "down out of the cell." The responsibility for this terminology is put upon Faraday.

The truth is that such statements do the great physicist and chemist an injustice. In order to establish a conventional idea of electrolysis that would not commit him to any hypothesis, the overthrow of which would render obsolete a system of nomenclature dependent upon it, Faraday sought some natural and permanent standard to which he might refer the proposed system. He decided upon the earth whose magnetism he considered the result of electric currents passing around the sphere from east to west. Establishing this as the conventional direction of his electric current, the anode became the eastern and the cathode the western terminus of the path of the current; the anode, then, was towards the rising sun and the cathode towards the setting sun. The sun rises "up" and sets "down." This is the conception upon which Faraday based his new terminology.

Another common deviation from the intentions of Faraday is the use of the terms anode and cathode to designate the electrodes of a cell whereby each becomes either positive or negative according to the portion of the circuit that is under discussion. In its original sense the term electrode indicated simply that conductor of the first class which is in contact with the anode or the cathode, and these latter are defined as the surfaces which bound the electrolytic solution at the electrodes. This idea removes a source of ambiguity which has been very confusing to students. If we accept this, Faraday's explicit definition, then the cathode will always be the positive extremity of the electrolytic liquid and the electrode in contact with it will always be negative while the corresponding pole will always be the positive pole of the cell; the anode will ever be the negative extremity of the electrolytic fluid, its electrode will always be positive and the corresponding pole will be negative. A clear statement of these relationships should remove the source of much of the confusion which has enveloped the subject.

Faraday's statement is as follows:[1]

In place of the term pole, I propose using that of *Electrode* (ἤλεκτρον and ὁδὸς *a way*), and I mean thereby that substance, or rather surface, whether of air, water, metal, or any other body, which bounds the extent of the decomposing matter in the direction of the electric current.

663. The surfaces at which, according to common phraseology, the electric current enters and leaves a decomposing body, are the most important places of action, and require to be distinguished apart from the poles, with which they are mostly, and the electrodes, with which they are always, in contact. Wishing for a natural standard of electric direction to which I might refer these, expressive of their difference and at the same time free from all theory, I have thought it might be found in the earth. If the magnetism of the earth be due to electric currents passing around it, the latter must be in a constant direction, which, according to the present usage of speech, would be from east to west, or, which will strengthen this help to the memory, that in which the sun appears to move. If in any case of electrodecomposition we consider the decomposing body as placed so that the current passing through it shall be in the same direction, and parallel to that supposed to exist in the earth, then the surfaces at which the electricity is passing into and out of the substance would have an invariable reference, and exhibit constantly the same relations of powers. Upon this notion we purpose calling that towards the east the *anode* (ἄνω *upwards*, and ὁδὸς *a way*; the way which the sun rises), and that towards the west the *cathode* (κατὰ *downwards*, and ὁδὸς *a way*; the way which the sun sets); and whatever changes may take place in our views of the nature of electricity and electrical action, as they must affect the *natural standard* referred to, in the same direction, and to an equal amount with any decomposing substances to which these terms may at any time be applied, there seems no reason to expect that they will lead to confusion, or tend in any way to support false views. The *anode* is therefore that surface at which the electric current, according to our present expression, enters: it is the negative extremity of the decomposing body; is where oxygen, chlorine, acids, etc., are evolved, and is against or opposite the positive electrode. The *cathode* is that surface at which the current leaves the decomposing body, and is its positive extremity; the combustible bodies, metals, alkalies and bases, are evolved there, and it is in contact with the negative electrode.

JAMES F. COUCH

WASHINGTON, D. C.

THE SYNCHRONOUS FLASHING OF FIREFLIES

SEVERAL years ago I published in SCIENCE a few brief letters on the synchronous flashing of fireflies which led to other observations and discussions on the subject. In the magazine *Asia* for February, 1924, is an article by Carveth Wells on his experiences in the

[1] "Experimental Researches in Electricity," 1, 196–7, 1839.

Malay Peninsula. The following extract describing the flashing in unison of fireflies will be of interest to those who have studied the subject:

One evening I saw a demonstration of insect organization which I believe it is impossible to explain. It was a beautiful night. The air was full of extraordinary fireflies. About every fifteen minutes these flies separated into two armies, one settling on the trees growing on the left bank of the river and the other on the right. Then, when I had decided that the fireflies had gone to bed for the night, the whole army on the left bank gave one big flash in perfect unison, which was immediately answered by another big flash from the right. How those flies managed to keep time absolutely beats me, but they did so, though there must have been thousands of them stretching along the river-banks for a hundred yards or more. The illumination was so strong that the branches of the trees could be seen quite distinctly.

EDWARD S. MORSE

THE PROBLEM OF THE MONKEY AND THE WEIGHT

THE following simple, interesting and instructive problem in mechanics, though old, is still of interest as different answers are given by those whose opinions are to be respected and who ought to agree.

A supposedly weightless rope passing over a frictionless pulley has a 10 lb. weight hanging on one end and a 10 lb. monkey on the other. What will happen when the monkey climbs up the rope.

We are told that the correct answer is that the weight will move up as fast as the monkey and that they will ultimately meet at the top. The monkey, therefore, does twice the work of lifting himself to that height. This is said to have been crudely confirmed by a boy who found it far more difficult to pull himself up in such a case than when the top of the rope was immovably secured.

It seems necessary to distinguish between a jerky and a uniform movement of the monkey; the former involves acceleration, deceleration and inertia. It is claimed that with a uniform motion the weight would not move, as the monkey can not pull with a greater force than his weight. And that with a jerky upward motion of the monkey, involving acceleration and deceleration, the weight would move up and down for each jerk, but its average and ultimate position would remain the same. Others claim that the weight would move up with every jerk, but would not descend again during the deceleration, hence its ultimate upward motion would be equal to that of the monkey. A spring or elastic rope introduces another complication.

For a uniform motion the problem may be put in a simpler form. Suppose a motor suspended on a rope moves itself up or down fast but at a uniform velocity, by winding or unwinding the rope around its shaft. Will the tension on the rope then be greater or less respectively than that when the motor is at rest?

The problem is not without practical value.

CARL HERING

PHILADELPHIA, OCTOBER 16, 1923

THE PROFESSOR AND HIS WAGES

The Professor, God bless him, he works long and hard,
And diplomas and medals are his sole reward.
On "Love of his work" he must feed his dear own,
With a pleasant smile and never a groan.

He must move in society; live with the best;
He must be very careful of how he is dressed;
He must buy many books and must study at night;
Everything that he does must be proper and right.

He must never have children, it's vulgar and bad,
And besides, who would feed them, supposing he had?
He must not smoke a pipe, for that wouldn't be nice,
And he can't smoke cigars, for he hasn't the price.

To the theater he is permitted to go,
But he rarely does so for it takes too much dough.
He must always be cheerful before every class,
Though bills through his mind ever, endlessly pass.

And while he is teaching, his dear wife must scrub;
She must manage her part with a mop and a tub;
But she has her own pleasures as well as does he,
They are solely the Women's Club's afternoon tea.

These things are quite bad, you in truth will concede,
But to make matters worse, he in SCIENCE must read
That he's paid all he's worth and should be quite content
With a pittance that scarcely pays for his rent.

The Professor, God bless him, I take off my hat
To a man who has courage to face all of that.
Nothing short of a genius could ever pull through
And accomplish what he is required to do.

ANON

CORRECTIONS

THE article entitled "Gels and Theory of Adsorption" given in the December fourteenth issue of SCIENCE reads on page 496 as follows:

$pH < 1.217$ $pH > 1.217$

but should read:

$pH > 1.217$ $pH < 1.217$

NEIL E. GORDON

In SCIENCE, 1924, p. 10, first column, line 2 up, for "eighteen" read "thirty-one."

F. CAJORI

SCIENTIFIC BOOKS

THE WEBER SEVENTY-YEAR BOOK

A "FEEST-NUMMER" of the "Bijdragen tot de Dierkunde" in an edition de luxe has been lately issued by the Royal Zoological Society, "Natura Artis Magis-

tra," of Amsterdam. This imposing volume celebrates the seventieth birthday of Dr. Max Weber, senior professor of zoology in the University of Amsterdam.

This tireless and capable investigator, of whom an excellent portrait is given, has devoted himself for many years to the study of the fauna of New Guinea and neighboring parts of the Pacific. He has interested himself particularly in the fish-fauna, transitional between the tropical "South Seas" and the continental fauna of Australia. His work has been throughout of a high order. Beginning in 1895, with the fishes of Semon's voyage to New Guinea, he has continued in active research to the present time. Twenty-eight new genera, all of them apparently valid, have been described by him, with the cooperation, in part, of his able associate, Dr. Louis F. de Beaufort. The majority of these new forms were taken in the Siboga expedition, about 1913.

In this memorial volume, 44 authors are represented. The list includes most of the naturalists of the Netherlands, several from Germany and Scandinavia, one (Dollo) from Belgium, two (Regan and Hickson) from England, one (Annandale) from India, and three (Eigenmann, A. H. Clarke and Jordan) from the United States. The essays are extremely varied and those within the comprehension of the present writer, important and interesting.

DAVID STARR JORDAN

Nutrition, The Chemistry of Life. By LAFAYETTE B. MENDEL, Sterling Professor of Physiological Chemistry, Yale University. The Yale University Press, 1923.

THE book, which contains 150 pages, represents the Hitchcock Lectures delivered by the author at the University of California in 1923. It is stated in the preface that no attempt has been made to present an elaborate summary of the current knowledge of the subject. Indeed, it would have been impossible to do so in the compass of a book of this size.

The book is divided into five chapters: The science of nutrition: a retrospect. The importance of "Little Things" in nutrition, The vitamines, The protein factor in nutrition, and The energy problem in nutrition.

There is an individuality possessed by this little book which makes it very different from any other which has yet appeared on the subject. In the first chapter the views of Magendie, Beaumont, Prout, Liebig, Mulder and Voit on nutrition are set forth in a most entertaining way.

In subsequent chapters a wise selection is made of material from the great volume of experimental data now available for presentation to a popular audience. The story of modern research is told simply and embellished with illustrations which make an appeal to a wide circle of readers. Dr. Mendel's extraordinary ability as a lecturer and teacher is reflected in this series of lectures.

E. V. MCCOLLUM

LABORATORY APPARATUS AND METHODS

A CONVENTIONAL SCHEME FOR TEACHING CELL DIVISION (MITOSIS)

So far as I am aware all the conventional schemes for teaching mitosis are defective in at least four points: (1) They do not emphasize the cyclic nature of the phenomenon. (2) Certain phases are too long and too much involved. (3) The processes are not clear cut. (4) Certain steps that normally occur at least in some forms are omitted. For fear that any one may think that my criticisms are too severe, let us examine each in detail.

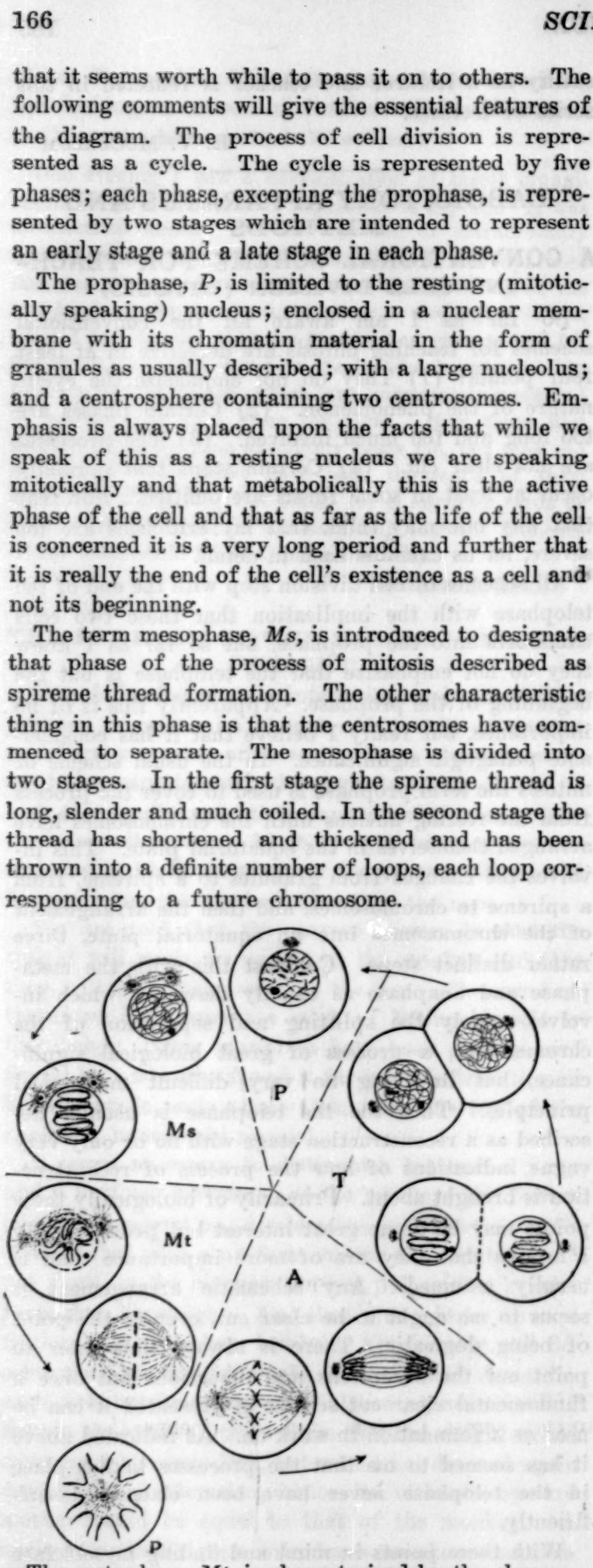
All schemes of cell division stop with the end of the telophase with the implication that these two cells transform into the prophase, but so far as I know they do not emphasize that the telophase is but the beginning of the prophase. Apparently this is of no importance, but really I believe that it has considerable pedagogic significance. In the usual scheme of mitosis the term prophase is used to cover the process from the resting nucleus until the chromosomes have arranged themselves in the equatorial plate. This involves the changes from granules to a spireme, from a spireme to chromosomes, and then the arrangement of the chromosomes into an equatorial plate, three rather distinct steps. Contrast this with the metaphase and anaphase as usually described which involves merely the splitting and separation of the chromosomes, a process of great biological significance, but involving no very difficult mechanical principles. Then too the telophase is usually described as a reconstruction stage with no or only very vague indications of how the process of reconstruction is brought about. Primarily or biologically these points may be of no great interest but pedagogically I believe that they are of more importance than is usually assumed. Any schematic arrangement it seems to me ought to be clear cut, even to the point of being dogmatic. There is always time later to point out the exceptions and deviations but once a fundamental clear cut scheme is presented it can be used as a foundation to work on. As indicated above it has seemed to me that the processes taking place in the telophase never have been elaborated sufficiently.

With these points in mind and finding myself face to face with the problem of teaching cell division to a large class in general embryology several years ago, I designed a chart which I have been using ever since. This chart seems to be so helpful in getting students to understand the complicated process of cell division

that it seems worth while to pass it on to others. The following comments will give the essential features of the diagram. The process of cell division is represented as a cycle. The cycle is represented by five phases; each phase, excepting the prophase, is represented by two stages which are intended to represent an early stage and a late stage in each phase.

The prophase, *P*, is limited to the resting (mitotically speaking) nucleus; enclosed in a nuclear membrane with its chromatin material in the form of granules as usually described; with a large nucleolus; and a centrosphere containing two centrosomes. Emphasis is always placed upon the facts that while we speak of this as a resting nucleus we are speaking mitotically and that metabolically this is the active phase of the cell and that as far as the life of the cell is concerned it is a very long period and further that it is really the end of the cell's existence as a cell and not its beginning.

The term mesophase, *Ms*, is introduced to designate that phase of the process of mitosis described as spireme thread formation. The other characteristic thing in this phase is that the centrosomes have commenced to separate. The mesophase is divided into two stages. In the first stage the spireme thread is long, slender and much coiled. In the second stage the thread has shortened and thickened and has been thrown into a definite number of loops, each loop corresponding to a future chromosome.



The metaphase, *Mt*, is characterized by the chromosomes. The chromosomes are represented as the broken loops of the short looped spireme thread. Another character is the disappearance of the nuclear membrane. In the first stage the chromosomes are represented as being scattered in the cell, while the centrosomes are about 90° from each other. In the second stage the centrosomes have reached their polar positions, 180° from each other, and the chromosomes have arranged themselves at the equator. Both equatorial and polar views, *p*, of this stage are shown for the sake of clearness. Attention is usually called to the disappearance of the nucleolus during this stage. Mitosis may be said to have reached its climax with this stage and all the rest of the process may be described as a process of reconstruction of the chromatin material.

The anaphase, *A*, means that time during mitosis when there are daughter chromosomes in the cell. It starts with the first indications of the splitting of the chromosomes and ends with them arranged at the poles. The first stage shows the beginning of the splitting and the second stage shows the chromosomes pulled to the poles and the division of the cytoplasm started. The centrosomes have usually divided by this time in preparation for the next mitosis, and the nucleolus has usually reappeared.

The telophase, *T*, may be described as the daughter spireme phase. In the first stage we have short thick looped daughter spireme threads formed apparently by the growing together of the ends of the looped chromosomes. This stage is exactly comparable with the second stage of the mesophase save that we are now "back-tracking" and have daughter spireme threads instead of a single thread. The nuclear membrane has reformed and the cytoplasmic division is usually complete. In the second stage we have long daughter spireme threads which are comparable to the first stage of the mesophase and the interesting process of mitosis is all but finished for there remains but the single step, the transformation of the thread into scattered granules and we are back with daughter prophase stages ready to start the whole process over again. And while in the minds of the older students who have learned the old nomenclature we may have appeared to add to the confusion by introducing new terms and by limiting old terms in a new way, and to have simply run round in a circle and arrived nowhere, yet my experience with beginning students leads me to believe that there is some little merit in it.

Z. P. METCALF

NORTH CAROLINA STATE COLLEGE
AND EXPERIMENT STATION

SPECIAL ARTICLES

OSCILLATIONS IN THE LOW VOLTAGE HELIUM ARC

R. BÄR, M. v Laue and E. Meyer have recently published a paper[1] explaining the apparent main-

[1] *Zs. f. Phys.*, 20, p. 83 (1923).

tenance of the helium arc at voltages below the first radiating potential.[2] They find that the voltage across the arc is not constant, but fluctuates periodically between a value above the first radiating potential (19.8 v.) and a much lower value. The apparent voltage as read on a direct current meter is a time average of the actual variable voltage. They conclude that the oscillations can be maintained only when the circuit contains inductance in series with the arc.

The writers had independently noticed these oscillations, and come to the same conclusion, that the arc is only possible provided the voltage in part of the cycle rises above the lowest critical potential of the gas. Similar oscillations were also found in mercury vapor arcs, where the peak voltage always exceeded the first resonance potential 4.9 volts. In the diatomic gases hydrogen and nitrogen, no oscillations of this kind were detected. The results of the investigation have led us to an interpretation of the essential features of these oscillations, as described briefly in the following paragraphs.

The arcs are maintained between a hot filament cathode and a cold anode distant about 5 mm in the gas at an optimum pressure of 3 or 4 mm. In the simplest circuit a control resistance is placed in series with the arc and source of e. m. f. Contrary to the conclusions of Bär, von Laue and Meyer, we have not found inductance in the circuit to be essential, although the presence of inductance or capacity has an effect (smaller than might be expected) on the frequency of the oscillations and their wave form. These authors used a source of current whose electromotive force was 12 volts, *i.e.*, less than the first radiating potential. As the principal characteristic of these oscillations is that the maximum voltage attained is greater than the first radiating potential, the necessity of inductance with so low an electromotive force does not establish its fundamental relation to the phenomenon.

We have succeeded in maintaining the oscillations in a circuit whose inductance is as nearly as possible eliminated, but whose battery electromotive force was larger than 20 volts, usually 120 volts, and whose series resistance was quite high. In a typical case the minimum of the current voltage curve[3] as determined with direct current instruments was, at 306 ma., 17.6 volts. The corresponding maximum and minimum voltages, measured with a peak voltmeter, were 22.8 and 15.9 volts, respectively.

The writers have also found two distinct types of oscillation in the arc.

I. A type of oscillation which appeared when the direct current voltage across the tube first began to diminish with increasing current. This type was characterized by the following: (a) The maximum voltage (ca. 28 v) was above the ionizing potential; (b) The minimum voltage (ca. 16 v) was below the first radiating potential; (c) The direct current voltage was much nearer the maximum voltage than the minimum; (d) The amplitude of oscillation showed no marked variation as the resistance in the circuit was changed.

When the direct current voltmeter reading was reduced below about 25 volts, these oscillations stopped suddenly, and the arc was maintained without noticeable oscillations at about 20 volts. On decreasing the series resistance farther, the voltage dropped a few tenths of a volt, and the current rose, but no oscillations were detectable.

II. On further decreasing the series resistance, oscillations again set in. In this type: (a) The maximum voltage was above the first radiating potential, and below the ionizing potential; (b) The minimum voltage was below the first radiating potential; (c) The reading of the direct current voltmeter was usually nearer the minimum than the maximum voltage; (d) The amplitude showed a marked maximum at the minimum of the direct current-voltage curve.

We believe that some insight into the mechanism of these phenomena is obtained from the following considerations: Suppose the tube to be connected to a battery of, say 50 volts, through a non-inductive series resistance, so that the complicating effects of inductance will disappear. If the series resistance is very large, the current through the tube will be low, limited by a negative charge about the cathode. As the resistance is decreased, the voltage across the tube will increase, until ionization takes place. The positive ions will neutralize a portion of the negative space charge, allowing the current to increase. Finally the amount of ionization becomes so great that the charges must rearrange themselves in such a way that a positive space charge surrounds the cathode. This rearrangement allows the current to increase considerably, and the arc may be said to have "struck."

But this increase in the current must increase the voltage-drop across the series resistance, so that the voltage across the tube may drop below the lowest voltage at which ions are formed by *any* process. If this happens, the positive space charge must disappear. It will be replaced by a negative space charge, which will again reduce the current through the tube. This will allow the voltage across it to rise, whereupon the cycle will be repeated. It is the time required for the rearrangement of the space charge that

[2] K. T. Compton, E. G. Lilly and P. S. Olmstead, *Phys. Rev.*, 16, p. 282 (1920). A. C. Davies, *Proc. Roy. Soc.* (A) 100, p. 599 (1922).

[3] *Cf.* Compton, Lilly and Olmstead, *loc. cit.*, p. 286.

determines the period and wave form of the oscillations.

This investigation is being continued.

CARL H. ECKART,
K. T. COMPTON
PRINCETON UNIVERSITY

ON WALDEN-INVERSION

IN connection with the problem of Walden-Inversion, it is important to know whether the change in the polarity of a group attached to the asymmetric carbon atom is accompanied with a change of direction of optical rotation when the change of polarity is accomplished without resorting to substitution. It is realized that the result may depend on the polarity of the other elements attached to the asymmetric carbon atom. A systematic study in this direction is possible on substances of two groups; first on derivatives of secondary carbinols of the type R_1CHOHR_2 and second, on the derivatives of the primary alcohols of the type $\begin{matrix} R_1 \\ R_2 \end{matrix}\!\!>\!\!C\!\!\begin{matrix} H \\ - \end{matrix}\!\!-CH_2OH$. In both groups of substances the radicles R_1 and R_2 may be varied infinitely and in both of them, the polarity of one group may be changed without substitution. Both these groups of substances are now under investigation in our laboratory. Results have already been obtained on a derivative of the first group of substances.

Laevo-methylhexylcarbinol was converted by substitution into dextro bromide; this, in its turn, again by substitution into laevo-mercaptan and the latter by oxidation (without substitution) into dextro-sulfonic acid.

$$\underset{\text{laevo}}{C_6H_{13}CHOHCH_3} \rightarrow \underset{\text{dextro}}{C_6H_{13}CHBrCH_3}$$
$$\rightarrow \underset{\text{laevo}}{C_6H_{13}CHSHCH_3} \rightarrow \underset{\text{dextro}}{C_6H_{13}CHSO_3HCH_3}.$$

Thus, in this group of substances, the change in polarity, brought about with or without substitution on the asymmetric carbon atom, leads to a change in the direction of rotation.

P. A. LEVENE,
L. A. MIKESKA

THE RELATION OF CLIMATIC CONDITIONS TO THE SALT-PROPORTION REQUIREMENTS OF PLANTS IN SOLUTION CULTURES

ALTHOUGH it has been known for more than sixty years that many forms of higher green plants may be grown to maturity with their roots in an aqueous solution of a few inorganic salts, it is only in the last decade that attention has been seriously directed to the study of the relations that prevail between the nature of the solution thus used (kinds of salts, salt proportions and total salt concentration) and the amount and kind of growth exhibited by the plants. Since the publication of the earlier work in this field by Schreiner and Skinner, Tottingham, and Shive, many experimental studies have been made, by different investigators, with the aim of throwing light on this complex relation. Great difficulty has thus far been encountered, however, in obtaining satisfactory agreement or consistency, even by the same experimenter, between the results of two or more experiments planned and executed so as to be as nearly alike as possible with respect to the plants and solutions used. Similar difficulty is frequently encountered in many other lines of biological experimentation, whether with plants or animals.

In experimentation dealing with the influence of external conditions on the growth of any kind of plant, it is of course essential that all the individual plants of the same experiment should be as nearly alike as possible (in variety, race and physiological condition) at the outset of the experiment, and also that this same degree of similarity should obtain among all the plants of several experiments that are planned to give comparable results. But we can not be at all sure that variability among the plants with which the experiments are set up is satisfactorily cared for by employing seeds of a pure line, selecting them for uniformity of weight, germinating all seeds in the same way, and selecting the seedlings for likeness in size, robustness, and so forth. Even after taking all feasible precautions in this respect, internal variability is generally found to be far from negligible. The difficulty can of course be largely overcome by employing a great number of duplicates in every test. The number of duplicates needed naturally depends on the degree of precision required in the results and on the degree of internal variability that persists in the plants after care has been exercised in selection, and other experimental details. By using a sufficient number of duplicates, all cultures in a comparable series, whether in the same or in several experiments, may be made to represent the same quality and range of internal variability in the plants. It may be added that the plants at the beginning of an experiment should be adequately described. This is necessary in order that it may be known for just what sets of original internal conditions the experimental results may be considered as applicable, in order that the experiment may be repeated later, and in order that subsequent experimentation in general may be carried out so as to be comparable with earlier tests. Statistical methods are requisite for finding and stating what kinds and ranges of variability persist in the original plants. Also, statistical treatment of the experimental results

helps to indicate the relative degrees of significance to be assigned to the several resultant growth differences that are to be compared.

Assuming that the internal conditions of the plants at the outset of an experiment have been sufficiently well considered and cared for, the environmental complex of conditions deserves at least an equal degree of attention. In any experiment or series of experiments the influential features of the environment may be conveniently grouped in two categories: (1) Those that represent the variables to be specially studied, and (2) those representing the rest of the environmental complex. The influential conditions of the first category are assumed to be adequately known; they are the conditions that are purposely made to differ in certain known ways, from culture to culture. In water-culture experimentation these are usually the chemical or osmotic characteristics of the solutions tested. In studies on the physiological balance of salts in the solution about the roots, the several different solutions are usually prepared so as to supply just those chemical elements that are essential to the plants, and they are made to differ in certain known ways with regard to the relative partial concentrations of the salts. The salt proportions, or ion proportions, are the acknowledged and prearranged variables in such studies.

For an ideal experiment or experiment series the remaining influential environmental conditions (our second category) should of course each be the same for all cultures, and they should be as thoroughly known and as definitely described as are the acknowledged variables. Here belong the influential aerial conditions as well as those of the influential solution conditions that are not included in the first category. Among these solution conditions may be the kinds of salts used, the osmotic properties of the solutions tested, the rate of renewal of the solutions in the culture vessels, and so forth. Several solutions may be prepared to contain the same salts and to have the same osmotic value and they may all be renewed in the same way, while they differ in definite and known ways as to their salt proportions. These solution features are readily controlled to a high degree of precision, but the aerial features are not generally artificially controlled, nor are they quantitatively well known in most experimentation on the salt nutrition of higher plants.

Aside from the features of the environment that are readily controllable in nutrient solutions, the environmental influence on plant growth can as yet be analyzed only in a very superficial way. It is not yet feasible even to prepare a somewhat detailed list of the features that should usually be taken into account in culture studies such as we are considering, and the problem of controlling, or even that of measuring them is thus far almost untouched. A number of experimenters have attacked various separate phases of this problem and marked advances are being made, but the time is not yet ripe for any attempt to set up an experiment on the salt nutrition of higher plants with all the influential non-solution environmental conditions as well controlled and known as are the chemical and osmotic conditions of the solutions and the internal conditions of the culture plants at the beginning of the test. Nevertheless, it is of course easy to arrange a single experiment so that all cultures will be subjected to very nearly the *same* fluctuations in the aerial surroundings during an experiment period, even though these fluctuations are quite unknown. The rotating table introduced by Shive usually accomplishes this very satisfactorily, and Duggar's planetary rotation of each culture vessel on the main table is a still further refinement. The great difficulty arises when two comparable experiments are to be carried out on separate rotating tables or, more especially, at different times. In studying inconsistent results secured from two separate experiments in which the internal conditions of the original plants and the chemical features of the solutions used have been sufficiently well cared for, one thinks first of the climatic conditions as among those that may not have been effectively alike in the two cases. We have in mind especially air temperature, the temperature of the solutions in the culture vessels, the evaporating power of the air (including water vapor-pressure deficit and wind velocity, and the complex conditions of illumination. Other non-solution conditions may be influential, but these climatic ones are surely not to be generally neglected in solution-culture experiments. This suggestion has been advanced by several writers in this field.

We have recently completed some experiments that were planned to throw a little light on the question of how great may be the climatic differences between two experiments without rendering the results incomparable with reference to the problem of salt proportions. It seems safe to suppose that the time may eventually come when the relative physiological values of several salt solutions of the sort here considered may be determined for a given kind of higher plant, for a given period of its development, and for a given set of non-solution conditions, with considerable assurance that the same relative values may be repeatedly demonstrated by repetitions of the experiment at other times and places. Until this can be actually achieved, progress in this field must be mainly confined to studies aiming towards improvement of experimental methods and to generally vague or very special conclusions as to the real meaning of the concepts of physiologically balanced solutions, toxicity, salt antagonism, the influence of temperature

conditions, and so forth. Our experimental results may be of some use in preparing the way for what may be thought of as rather satisfactory standard demonstrations of the principles of the salt nutrition of higher plants. Plant physiology seems to have a long way to go before this simple ideal may be achieved, but it may be that the way will be traversed more rapidly than the most optimistic would dare predict.

We hope to present a fuller account of our experiments elsewhere, and the present report is only a preliminary summary of some selected features. We are indebted to Mrs. Helen M. Trelease for valuable assistance in the experimentation.

Eight very different solutions were tested simultaneously under two diverse sets of climatic conditions, the first climate being that of an ordinary greenhouse and the second that of a basement room with nearly constant temperature and with no light excepting that supplied by five 200-watt "Mazda C" electric lamps, which operated continuously. The experiment was carried out from February 6 to March 6, 1923, and it was repeated from March 11 to April 8, 1923.

"Marquis" spring wheat of a pure line was employed.[1] Selected seeds each weighing between 32.5 and 37.5 mg were germinated under largely controlled conditions, and selected seedlings (measuring between 4 and 5 cm in length of top, in the first experiment, and between 4.5 and 5.5 cm, in the second experiment) were mounted in cork stoppers, five seedlings in each stopper. The culture vessels were 3-gallon, cylindrical, glazed earthenware jars, nearly filled with solution and covered with a paraffined Portland cement disk having eight circular openings, in which were set the stoppers supporting the plants. There were forty seedlings in each culture. The cultures of each set stood near the edge of a continuously rotating table.

Each of the culture solutions had an osmotic value of approximately 1.00 atmosphere for a temperature of 25° C. The volume-molecular salt proportions of the three main salts (KH_2PO_4, $Ca(NO_3)_2$, $MgSO_4$) are given for each solution in the accompanying table. It will be noted that solution IV had equal proportions of the three main salts and that the several sets of salt proportions were selected so as to give, in all, a rather wide variation from this equality in all three directions. In addition to the three main salts each solution contained a small amount of ferrous sulphate, the partial concentration of this salt being 0.000005 M for the first seventeen days and 0.000017 M for the remaining eleven days. The solutions were all renewed every two days, each plant being thus supplied with solution at the average rate of about 131 cc per day.

At the end of the growth period (28 days) the top dry weight of each individual was determined. The means of the yield values, with their probable errors, are given in the table, in which each mean yield is followed by a number (relative value) in parenthesis, showing the mean as a percentage of the corresponding mean for solution VIII.

Considering the two sets with continuous illumination, we see that every solution gave a somewhat lower actual yield mean for the second experiment than for the first, which may possibly be related to slight differences between the two climatic complexes for the two periods. Each of the two corresponding relative values (in parenthesis in the table) may be considered as about the same, however. Furthermore, solution VIII, here considered as a control or standard, gave eight ninths as great a mean for the second experiment as for the first. It appears that the non-solution conditions of the second continuously illuminated set did not differ sufficiently from those of the first to produce very serious corresponding differences in the ways in which the plants reacted to the several solutions. For both sets the highest three means are, in descending order, for solutions VIII, IV and II, and the lowest three are, in ascending order, for solutions I, V and VII. On the whole the second experiment with continuous illumination seems to have been a very satisfactory duplication of the first.

The climatic differences between the two greenhouse sets must have been much greater (considering the seasonal difference and the probable direct influence of sunlight) than those between the two continuously illuminated sets, and this supposition corresponds with the fact that the standard solution (VIII) gave a mean yield 36 per cent. greater for the second experiment than for the first. A similar difference in actual yield means is shown for every one of the other solutions. When we consider the relative values, however, it is seen that the two for each solution are generally nearly the same. We are consequently brought to the conclusion that, although the second set of greenhouse conditions was uniformly much more favorable to growth than was the first set, yet the climatic difference between these two sets was not of a nature and magnitude sufficient to bring about any serious differences in the relative physiological values indicated for the several solutions. For these sets the highest three means are, in descending order, for solutions VIII, II and IV (both sets), and the lowest three are, in ascending order, for solutions I, VI and III (first set) or I, III and VI (second set). It appears that as far as the *relative* physiological values

[1] Marquis, Saskatchewan, No. 70, Selection No. 313, supplied by the University of Saskatchewan, through the kindness of Professor Manley Champlin.

of the several solutions are concerned, the second greenhouse experiment must be regarded as a very satisfactory duplication of the first.

The points thus far mentioned seem to indicate that satisfactory duplication of both *actual* and *relative* values may be expected in such duplicated experiments as these, if the climatic conditions are nearly enough duplicated—a little more nearly than was the case in our two continuous-illumination tests; and that just as satisfactory duplication of the *relative* physiological values may sometimes be secured even when the climatic complex of the second test is markedly different from that of the first—different enough to bring about a pronounced corresponding difference between the two *actual* yields for each solution. With a properly chosen difference between the two climatic complexes, we must suppose, however, that *both* actual and relative values must differ seriously. Support for this supposition is met with when we compare either greenhouse set with either continuously-illuminated set in our experiments.

Scrutinizing the two sets of values for the second experiment, we see that the standard solution (VIII) under greenhouse conditions gave an *actual* mean yield 2.31 times as great as was the corresponding mean for continuous illumination, and a similar relation holds for these two actual mean yields for each of the other solutions. On the other hand, outstanding differences are manifest between the two *relative* values for each of the four solutions, I, III, V and VI; the relative physiological values given for solutions I and V are definitely lower for continuous illumination, while those given for solutions III and VI are definitely higher. Nevertheless, the two sets of climatic conditions gave about the same relative values for each of the solutions, II, IV, VII and VIII. The great climatic difference here dealt with was without significant corresponding difference in the relative physiological values indicated for the four last-named solutions by the biological test. On the other hand, solutions I, V and VIII were much more nearly alike in physiological value when employed under greenhouse conditions than when employed in our basement room, and solutions III, VI and VIII were much more nearly alike when used in our basement room than when used in our greenhouse.

Notwithstanding the pronounced climatic difference between our greenhouse and our basement room, and although the former gave markedly larger actual yields than did the latter, yet the best three solutions are the same under both sets of conditions; as has been mentioned, they are, in descending order, solutions VIII, II and IV for the greenhouse climate and VIII, IV and II for the continuous-illumination climate. Similarly, solution I is poorest for both sets of climatic conditions. The second and third from the poorest are different for the two climates, however, being solutions VI and III (or III and VI) for the greenhouse and solutions V and VII for the basement room. The two medium solutions are numbers V and VII for the greenhouse and numbers III and VI for the basement room.

The general indications of these tests seem to be clear. If a number of markedly different nutrient solutions are repeatedly compared by biological tests made under different climatic complexes, the relative physiological values assigned to the several solutions may be either the same or more or less different for the several tests, according to the nature and magnitude of the climatic differences dealt with. It does not seem safe, in the present state of our knowledge of these things, to attempt to determine, with any

SALT PROPORTIONS OF NUTRIENT SOLUTIONS AND CORRESPONDING MEAN DRY WEIGHTS OF TOPS, WITH THEIR PROBABLE ERRORS; EACH NUMBER IN PARENTHESIS SHOWS THE RELATIVE YIELD EXPRESSED AS A PERCENTAGE OF THE CORRESPONDING YIELD FOR SOLUTION VIII.

Solution Number	Volume-Molecular Proportions of 3 Main Salts (KH_2PO_4:$Ca(NO_3)_2$:$MgSO_4$)	First Experiment (February 6 to March 6, 1923)		Second Experiment (March 11 to April 8, 1923)	
		Greenhouse Set	Continuously Illuminated Set	Greenhouse Set	Continuously Illuminated Set
		mg.	*mg.*	*mg.*	*mg.*
I	5 : 5 : 90	77.3 ± 1.1 (71)	37.1 ± 0.6 (51)	98.9 ± 1.3 (67)	29.4 ± 0.4 (46)
II	5 : 47.5 : 47.5	108.5 ± 1.3 (100)	66.5 ± 1.3 (92)	140.0 ± 1.5 (95)	59.9 ± 1.1 (93)
III	5 : 90 : 5	84.7 ± 1.2 (78)	64.3 ± 1.1 (89)	103.8 ± 1.5 (70)	59.4 ± 0.9 (93)
IV	33.3 : 33.3 : 33.3	104.2 ± 1.4 (96)	71.2 ± 1.2 (98)	136.7 ± 1.8 (92)	63.8 ± 0.9 (100)
V	47.5 : 5 : 47.5	90.5 ± 1.5 (83)	39.8 ± 0.7 (55)	120.7 ± 1.6 (81)	34.9 ± 0.7 (54)
VI	47.5 : 47.5 : 5	82.1 ± 1.2 (75)	66.5 ± 1.4 (92)	107.5 ± 1.5 (73)	58.8 ± 0.8 (92)
VII	90 : 5 : 5	88.0 ± 1.1 (81)	51.3 ± 1.0 (71)	125.9 ± 1.7 (85)	50.6 ± 0.7 (79)
VIII	50 : 18 : 32	108.9 ± 1.2 (100)	72.3 ± 1.1 (100)	148.1 ± 1.7 (100)	64.1 ± 0.7 (100)